

AN IMAGE BASED SYSTEM TO AUTOMATICALLY AND OBJECTIVELY SCORE THE DEGREE OF REDNESS AND SCALING IN PSORIASIS LESIONS.

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Abstract

In this work, a combined statistical and image analysis method to automatically evaluate the severity of scaling in psoriasis lesions is proposed. The method separates the different regions of the disease in the image and scores the degree of scaling based on the properties of these areas. The proposed method provides a solution to one of the present problems in dermatology: the lack of suitable methods to assess the lesion and to evaluate the changes during the treatment. An experiment over a collection of psoriasis images is conducted to test the performance of the method. Results show that the obtained scores are highly correlated with scores made by doctors. This and the fact that the obtained measures are continuous indicate the proposed method is a suitable tool to evaluate the lesion and to track the evolution of dermatological diseases.

Keywords: *psoriasis, exploratory data analysis, segmentation, decision trees, classification*

1 Introduction

One of the main problems in the treatment of dermatological diseases is the difficulty of tracking the evolution of the disease. Physicians are visited by the patients several times to control the evolution of the disease. However, due to the fact that no objective methods to summarize the lesion exist, physicians make scorings and take notes to document the actual condition of the patient. A drawback of this method is the dependency on the individual physician.

The advances in image analysis during the last decade have lead to the development of different methods to deal with related problems in the dermatological field. Engström [1] observed the effect of a new enzymatic debrider observing the evolution of the lesion area and the lesion color. These measurements were obtained from digitized photographs analyzed with a computer. Later, Hansen [2], developed an image system that included calibration for increasing the quality of the images. The system diagnoses burns and pressure ulcers in animals but the possibility of being used in humans was mentioned. In a recent paper, Hillebrand [3] used computer analysis in high resolution digital images to compare the skin condition of a group of females.

In this work, a method to objectively score the degree of scaling and redness in psoriasis is proposed. The method realises a hierarchical segmentation to isolate the different structures present in the image: normal skin, red area and scales. Different values are obtained from these areas and they are used to approximate the doctor scorings.

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2 Segmentation of the areas present in the lesion

Psoriasis is a dermatological disease characterized by red, thickened areas with silvery scales [4]. In order to score the degree of scales and redness in psoriasis, the first step is to segment the different areas in the lesion. The wide variety of forms and different levels of severity that psoriasis can exhibit makes this task highly complex.

2.1 Segmentation of the lesion

The segmentation of the disease with respect to the healthy area is based on the assumption, that under a suitable projection, both the normal skin and the lesion are distributed approximately as a Gaussian distribution. This assumption was supported by an exploratory data analysis of a small set of psoriasis images where several projections were considered. Furthermore, a principal component analysis [5] and an independent component analysis [6] on a dataset of 115 images indicated that the difference between the green and the blue band exhibits a good contrast to discriminate between the lesion and the normal skin. The distribution of this difference approximately follows a linear mixture of two Gaussians. The estimation of their means and variances makes it possible to identify the lesion by means of discriminant analysis. The parameters of the gaussians were estimated according to Tact [7]. Figure 1 shows the segmentation of the lesion.

2.2 Extracting the scales

Segmentation of the scales is complicated by the fact that scales may or may not appear in the image. If they appear they may range from a few spots to a large area. Moreover, non-uniformity of the areas with redness (ranging from red to brown) makes the task even harder. This variability implies that the lesion has to be considered in small areas where the change in redness is not significant. This can be accomplished with watersheds [8] to mark the different scales and then locally use a clustering algorithm [9] to segment them. This approach requires specifying the number of watersheds. In this work, the number of watersheds is determined in two steps. First a new image is created based in the watershed regions. Each watershed area is replaced by the minimum value of this area. This new image is then thresholded and the watersheds with values less than the threshold are the areas where the scales are detected. The method was tested on a set of psoriasis images and it demonstrated a good performance. However, the method had difficulties with some images that had problems during acquisition (especially shadows), so the number of watersheds was not found correctly. To solve this problem, the number of watersheds was fixed visually by a tuning parameter. The blue band was used to find the watersheds because a canonical analysis had shown that this band is the best to separate the scales from the red area. Figure 2 displays the segmentation of the scales.

2.3 Scoring the disease

Once the different areas have been segmented, a decision tree is created to automatically score the degree of scaling in the different images, approximating the scorings made by the physicians. Three variables are used as input to the model: the area of the scaling, the ratio between the area of scaling and the area of the lesion, and the ratio between the area of scaling and the area of redness. The whole procedure is shown in Figure 3.

In the evaluation of the redness, a canonical discriminant analysis over the difference of the mean values of the spectral values in the red and healthy area points out to approximate the physicians scorings using a clustering method as, e. g., a K- nearest neighbour.

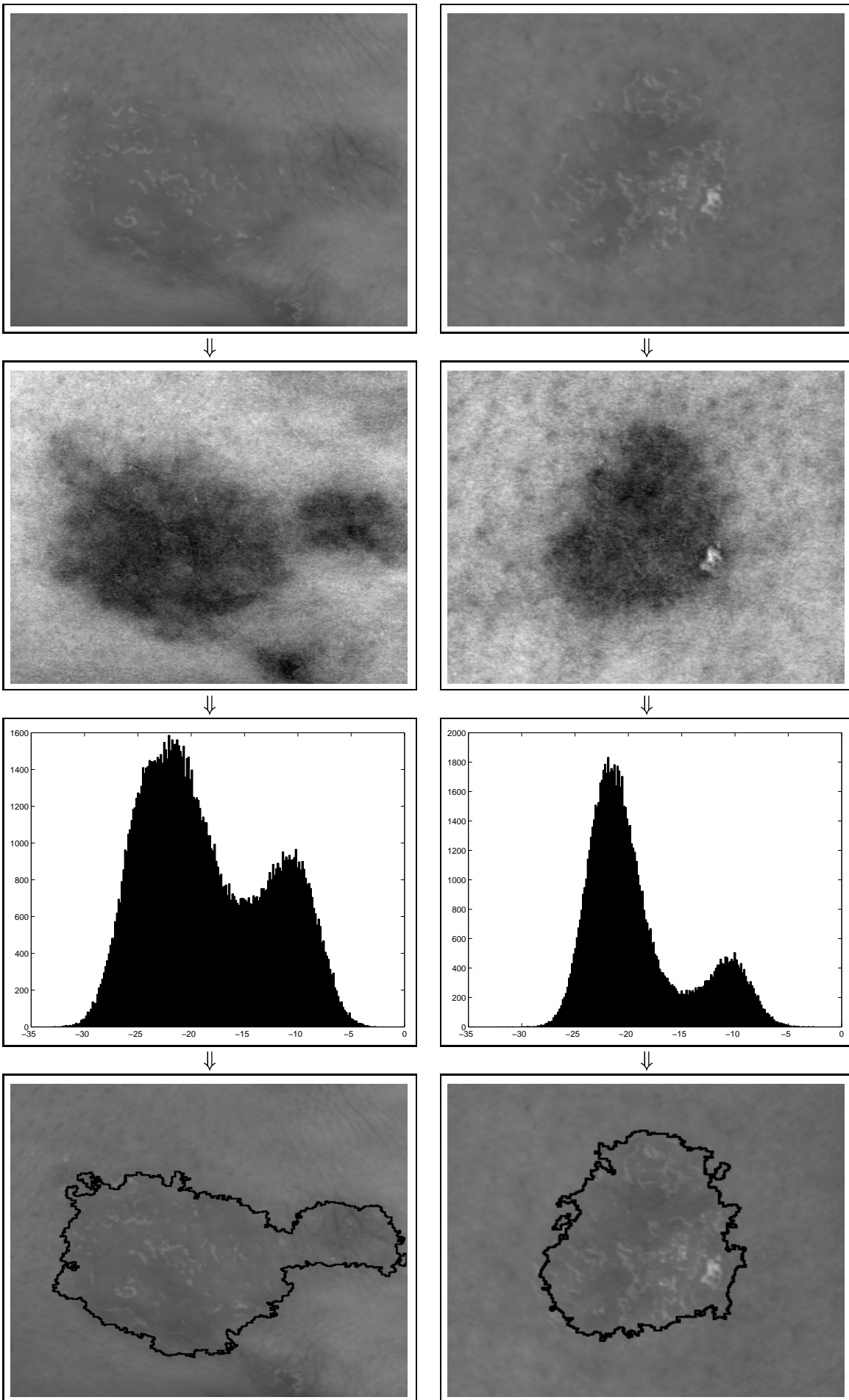


Figure 1: Top row: Two psoriasis images. Second row: Difference between the blue and green bands. Third row: Histogram of the band difference (blue minus green). Bottom row: Lesion segmentation result.

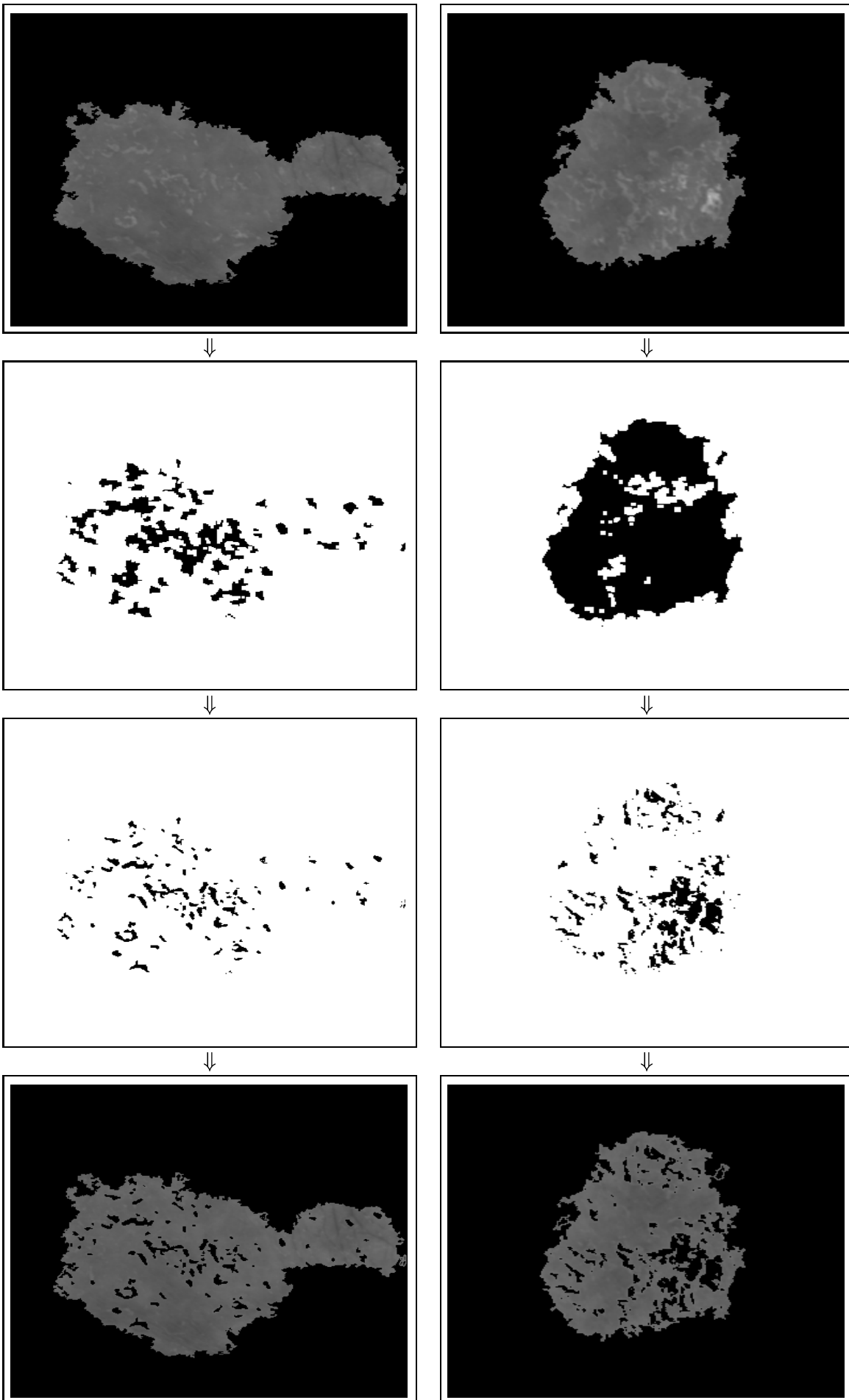


Figure 2: Top row: The original lesion. Second row: Scaling markers. Third row: Scaling segmentation result. Bottom row: A clear display of segmentation on top of the original image.

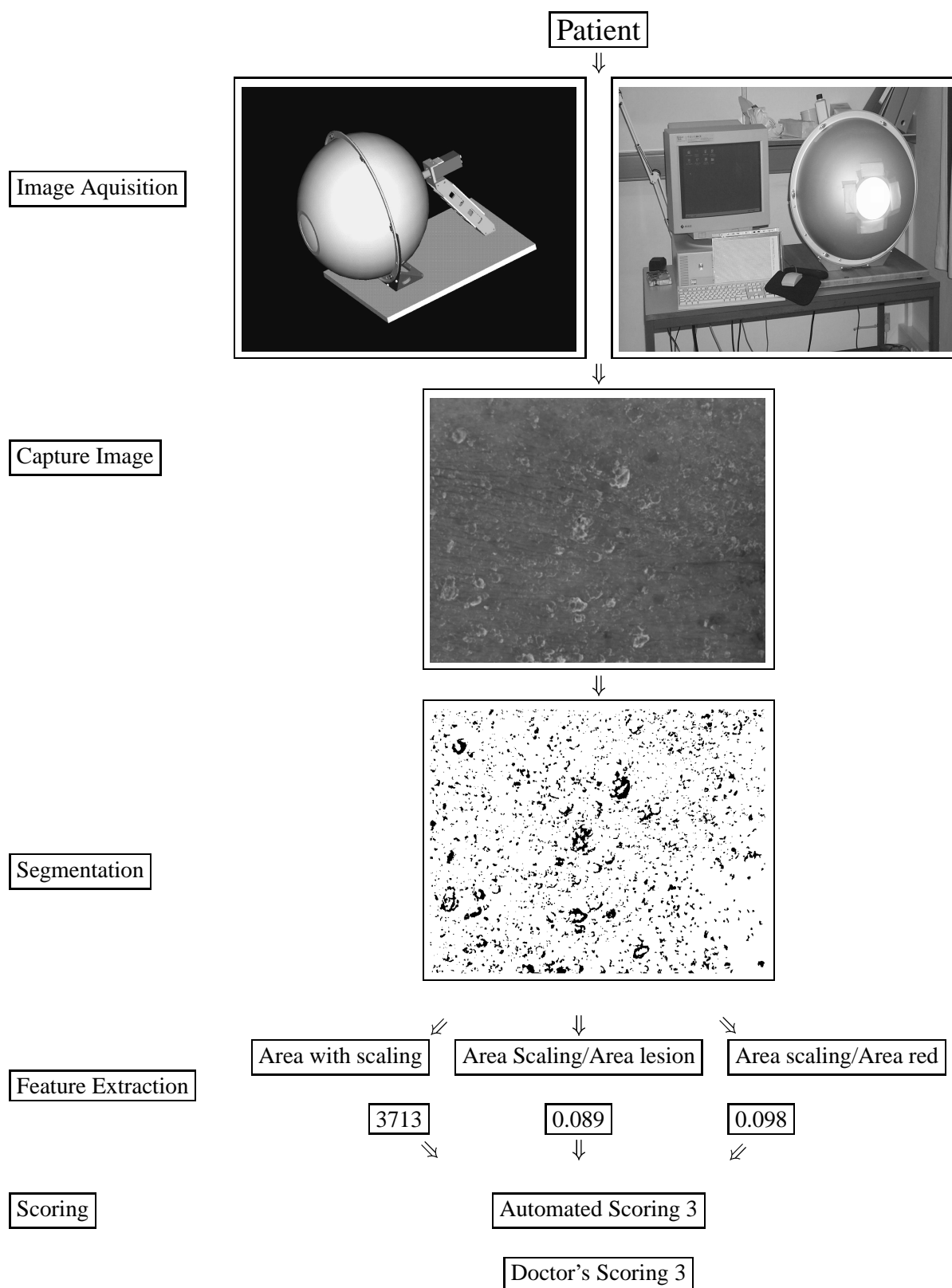


Figure 3: diagram of the method.

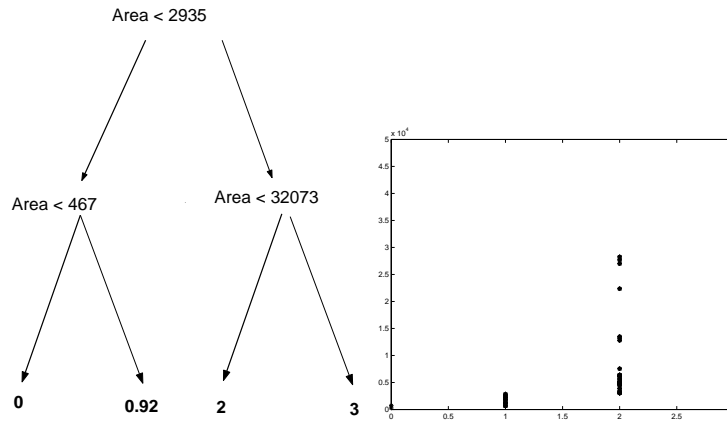


Figure 4: Left: Decision tree for the scoring given the parameters of the segmentation. Right: Dependency of lesion area on physicians' scoring of the lesions

3 Experiments

Two experiments are conducted to test the accuracy of the proposed method to score the scaling and redness in psoriasis lesions

3.1 First experiment: Scoring the degree of Scaling

In collaboration with the dermatological department of Gentofte Hospital in Denmark an experiment was conducted. The goal of the experiment is to objectively score the severity of the scaling in psoriasis images. To accomplish this goal, a set of 46 psoriasis images was selected from a database of psoriasis collected from different patients. The physicians scores of these images was also available. The images were selected to cover the maximal possible diversity. The different areas of each image were extracted according to the procedure described in the previous sections and the above mentioned three summary values were obtained. A cross-validation process was used to build 23 decision trees. These decision trees utilized 44 data points to build the tree and two for testing it. Results showed that the first variable, the area of the scaling, is enough to explain the physicians scoring. The automated scoring with our method has proven reliable, and on several occasions even allowed for corrections of physicians' mistakes. In these cases, the physicians were asked to re-score their previous judgements, and in all cases the assessment was changed.

Figure 4 left shows the final tree generated using all the points. Figure 4 right plots the area of the scaling versus the physicians' scoring.

3.2 Second experiment: Classifying the severity of redness

The second experiment aims to assess the possibility of automatically scoring the degree of the redness of the lesion. To achieve this goal, a set composed of 77 images of psoriasis lesions was selected from a data set with 175 images to perform the experiment. The selected images do not present shadows, scars or other elements that could spoil the result of the experiment. The severity of redness for each image was scored by the physicians in order to have a reference measure. The different areas involved in the chosen images were segmented according to the procedure described previously. The mean of the tri-chromatic bands was calculated in the healthy and in the red skin area for each image. The difference of these two means showed to be a good feature to evaluate the lesion.

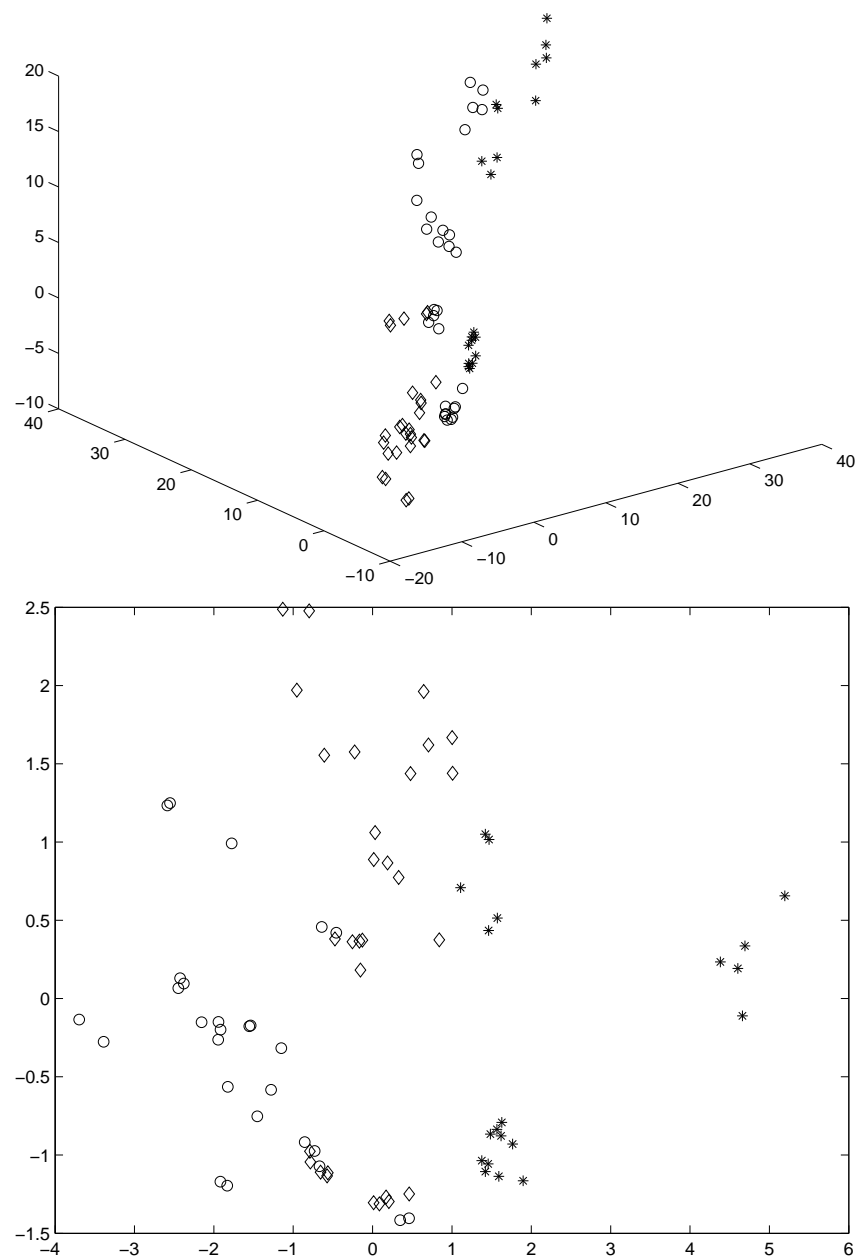


Figure 5: Up: 3D plot of the variables considered to classify the redness. Down: Result of applying a canonical discriminant analysis to the three selected variables to classify the redness

Figure 5 left shows a 3D plot of the differences where the different symbols represent different physicians scorings. The presence of three defined groups indicates the possibility of classify the redness using a clustering algorithm. This suggestion is even more clear if a canonical discriminant analysis is realized as it can be noticed in Figure 5.

4 Summary and conclusion

In this work, a procedure to evaluate the severity of the scaling and redness in psoriasis has been developed. The method automatically separates the different parts and extracts different parameters. In certain difficult cases such as uneven illumination it has been noticed that, allowing a manual interaction increases the accuracy notably.

The method provides objective measures that avoid the dependence of the physician in the tracking of dermatological diseases. It has been shown that one of the provided measures is highly correlated with the doctor scoring. Together with the other two measures we expect to be able to provide a better lesion description.

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